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On our way to a more cognitive indoor route planning algorithm

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Abstract. In current indoor navigation systems, the paths along which people are guided are shortest paths or derivatives. A cognitive route planning algorithm that calculates cognitive more comfortable paths, improves these existing systems by guiding people along more intuitive and easier-to-follow paths. The development of such an algorithm entails the identification of the aspects of the indoor environment inducing cognitive load during navigation. To identify these relevant aspects, a user study is enrolled: an in-depth discussion with experts is followed by an international online survey. Additionally, an experiment in a real indoor environment will be executed.

Keywords. Indoor navigation, Cognition, Route planning algorithm

1. Background

Indoor navigation is a challenging task for many people. The increasing availability of mobile devices could aid people while navigating in these complex indoor environments. This research only focusses on the route planning aspect of these systems. It determines the route between origin and destination and is one of the main aspects of navigation guidance (Montello 2005).

The supporting route planning algorithms in indoor navigation systems are limited to the currently known shortest path algorithms (or derivatives) (Vanclooster et al. 2014a), whereas studies have proven that people do not always prefer shortest paths (Golledge 1999). Developing a more appropriate wayfinding algorithm, taking into account other criteria than the distance to calculate the routes, will be a substantial improvement in this area.

In outdoor navigation, different route planning algorithms have been proposed to compute optimal routes other than shortest or fastest ones. The algorithms consider number of turns, angles and complexity, among other factors, to calculate a more optimal path. These route algorithms provide more intuitive and easier-to-follow routes, reduce the risk of getting lost, require a smaller wayfinding effort, aid in recalling routes and are overall perceived as more comfortable. Vanclooster et al. (2014a) demonstrated that the use of these existing algorithms in an indoor environment lead to unrealistic results and thus these outdoor alternatives have to be adapted to the indoor environment to be able to use them in the indoor environment.

A cognitive route planning algorithm will optimise the cognitive load during navigation. Cognitive load during navigation is considered as the effort it takes for people processing the information to navigate from origin to destination. Thus, this algorithm calculates the so-called cognitive more comfortable or cognitive less demanding paths.

2. Research question

In the first phase of the development of this cognitive route planning algorithm, we have to identify cognitive load in the indoor environment. What are the sources of cognitive load during indoor navigation? Which sources of cognitive load are related to the path that is followed?

In the following phase, focus will be on the theoretical conceptualization of the underlying spatial concepts of these aspects inducing cognitive load and how to match them with the users' perception.

3. Approach

To obtain a well-founded and coherent selection of aspects that induce cognitive load while navigating and to incorporate the definition of the user requirements into the design process, a focus group and an online survey are employed. This will be followed by an experiment in a real indoor environment recording thinking aloud data and eye-tracking data.

The focus group (12 participants) is composed of diverse academic researchers and experts, experienced with indoor environments, navigation and human behaviour studies. This focus group helps to define and formulate, through multiple discussions, the aspects that should be considered when evaluating cognitive load during wayfinding. In order to structure the discussions, the GPS-method, a guided brainstorm method, developed by the Flanders District of Creativity, was employed. The discussions are guid-

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ed by a rotating wheel. The focus group takes approximately 3 hours. It consists of open discussions to define the main topics, followed by two-by-two discussions and finished with selection of the most innovative or outstanding aspects that where brought up. This method encourages everyone to participate, is less influenced by the moderator and has a selection procedure of the most supported ideas that where introduced.

In the online survey, a large group and a diverse range of participants can be reached. Different recorded routes in various indoor environments are displayed to the participants. Subsequently, participants are asked to answer 2 questions about these routes: how comfortable they feel about the situation and how confusing they think the situation is. General demographic information and characteristics (e.g. age, sex, education level) of each participant is collected as well. The online survey is published on Amazon Mechanical Turk. Through this platform, a group of participants is recruited as a valid sample of the general international public that is diverse enough with respect to their personal characteristics and large enough so that a robust statistical analysis can be applied to the survey data.

Communication with potential users of indoor navigation systems, both with and without expertise, in an early stage in the project has two advantages. First, participants get closely involved in the project as they can follow its progress from the initial stage. Second, obtaining user input at the beginning of novel research is vital to obtain a result that is keyed to the end user's need: early input can easily be integrated in the subsequent steps. Integrating the results of the focus group, the online survey and the experiment leads to a coherent selection of relevant characteristics and provides complementary information on the main path characteristics in the indoor environment.

4. Conclusion and future work

This research will provide knowledge on human wayfinding in the indoor environment. More specifically, on the aspects of the navigation process that induce cognitive load. Not only will this research contribute to make navigation aid more comfortable, but it will also provide essential insights on the overall understanding of indoor navigation and wayfinding.

The focus group discussions and online survey will be followed by an experiment in the real indoor environment recording thinking aloud data and eye-tracking data. Through this integration of different qualitative and quantitative data acquisition techniques, the relevant path characteristics that differentiate a more intuitive path from the currently used indoor shortest or fastest paths (e.g. Kwan and Lee 2005; Thill et al. 2011) are defined.

To implement the obtained characteristics in a cognitive route planning algorithm, a theoretical conceptualization of the underlying spatial concepts of each of those path characteristics is needed. This conceptualization has to match the users' perception on these path characteristics. The underlying indoor spatial model has to be taken into account in this process, as this determines the structure of the algorithm and could influence the results and accuracy of the algorithmic implementation (Vanclooster et al. 2014b).

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